

Cyclic locust invasions explained through a multi-agent model



The context

Locusts are grasshoppers able to form devastating swarms. The strategy of preventive control of plagues consists in locating and destroying the locusts starting to change behaviour from solitarious individuals to dense group of gregarious. Preventive management of locust plagues works in some areas or species but still fails elsewhere.

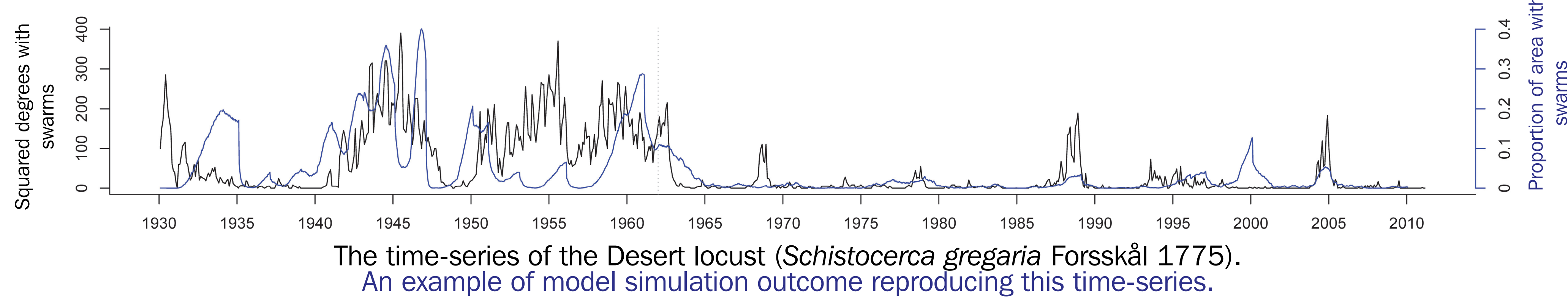
The role of funding institution awareness was questioned as potential facilitating factors of cyclic locust plagues.

The model

We designed a multi-agent system to represent theoretically:

- the natural stochastic events of locust plagues development,
- a hierarchical management system with three levels: a funding institution, a national locust control unit and field teams surveying and controlling locusts.

We used a pattern-oriented modelling approach to adjust locust dynamics, environmental parameters and agents' behaviours in order to reproduce time series of observation of Desert locust swarms on its distribution area.

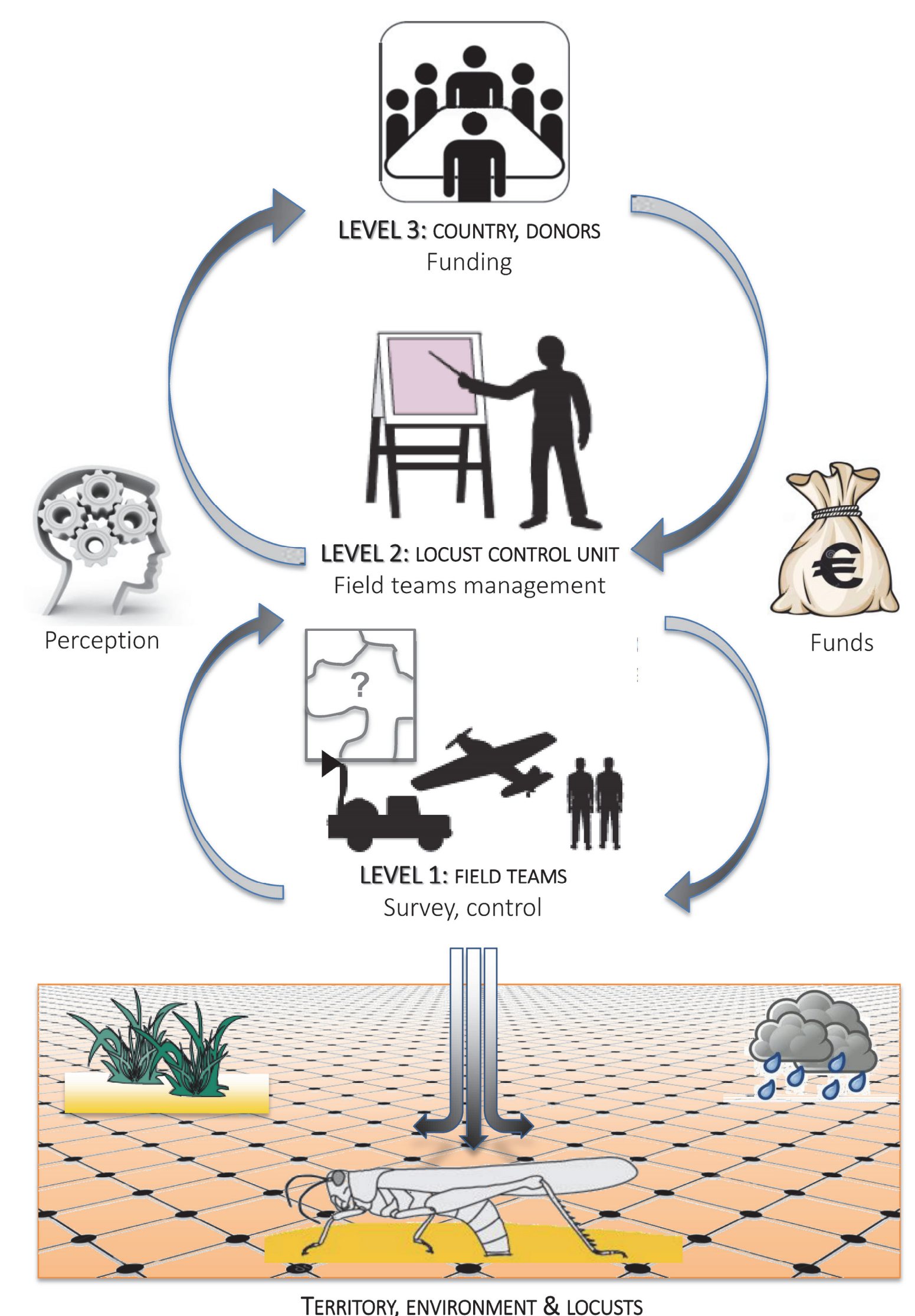


We conducted a sensitivity analysis of the model to identify the potential limits and improvements of the management system, using a one-at-a-time approach and making parameters vary on a range of realistic values.

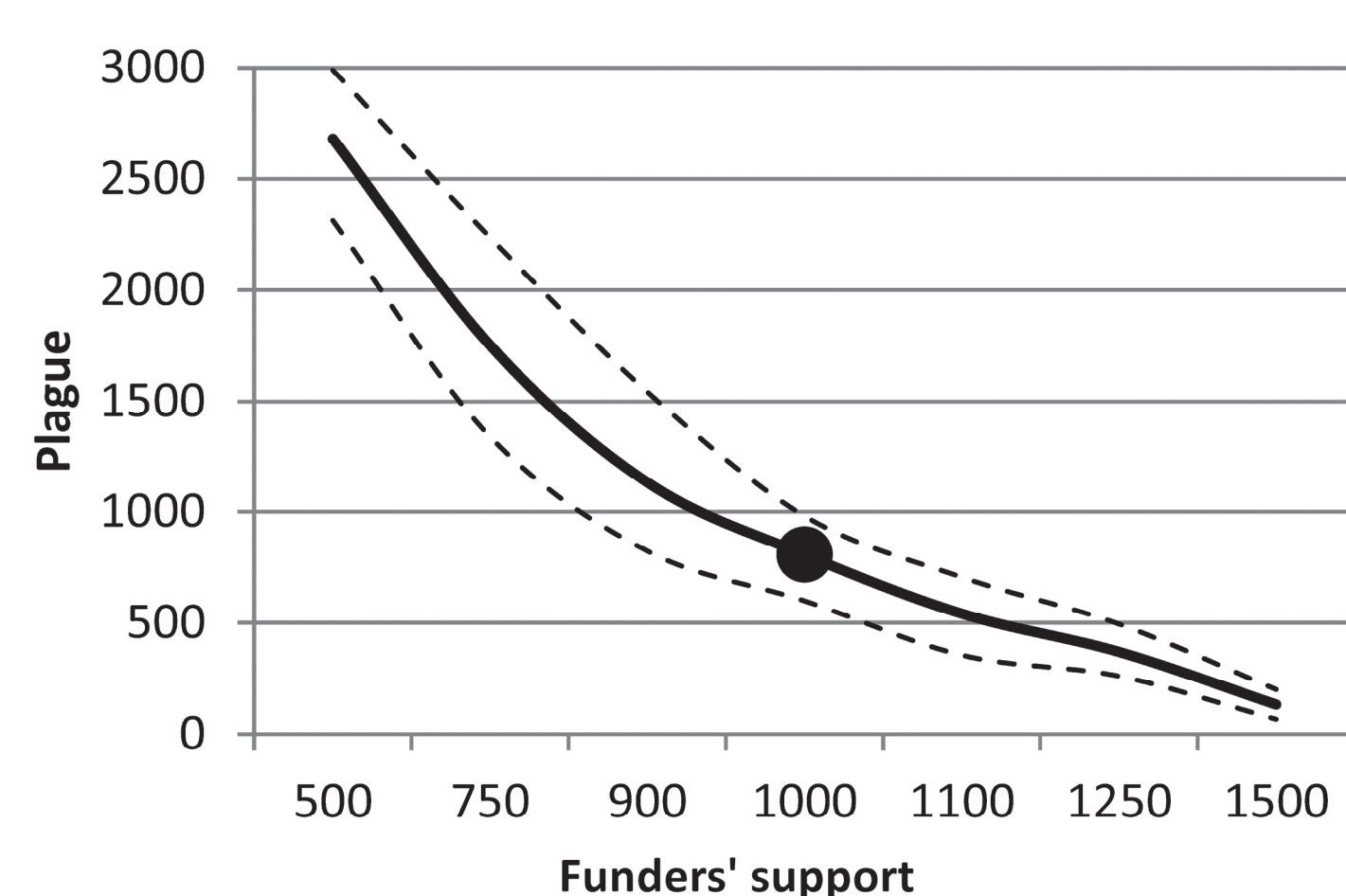
For each test, 30 simulations with 100 years duration were run. We measured the importance on the infestation, expressed by the number of time-steps (10-day periods) when an infestation was considered.

The main lessons

The model generated cyclic locust plagues through a decrease of awareness of funding institutions.



The three levels of the locust management system.



Effect of variation of funders' support on the plague.

The more information about the natural system the field teams can have, the more efficient they are → The more the surveys are expanded and the better they are targeted, the lower the invasion is.

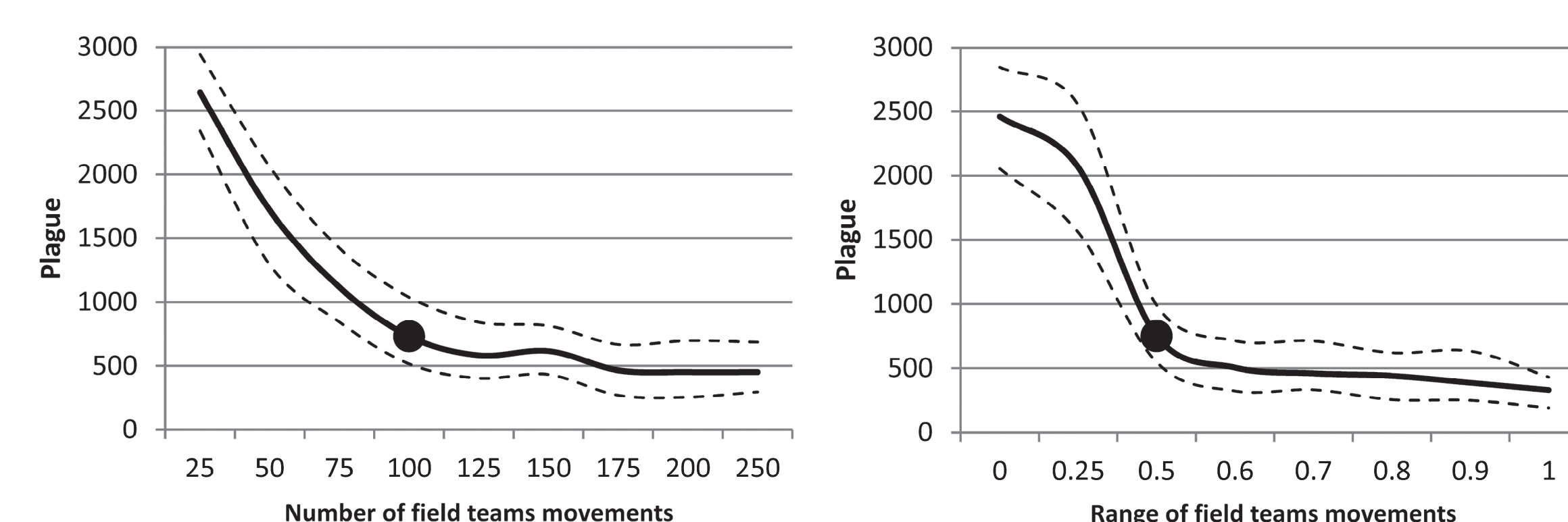
Points in the charts represent the default value set by the parametrization process. Dotted lines represent the 5% and 95% percentiles.

← Increasing the allocated budget by 10% reduces the invasion by one-third

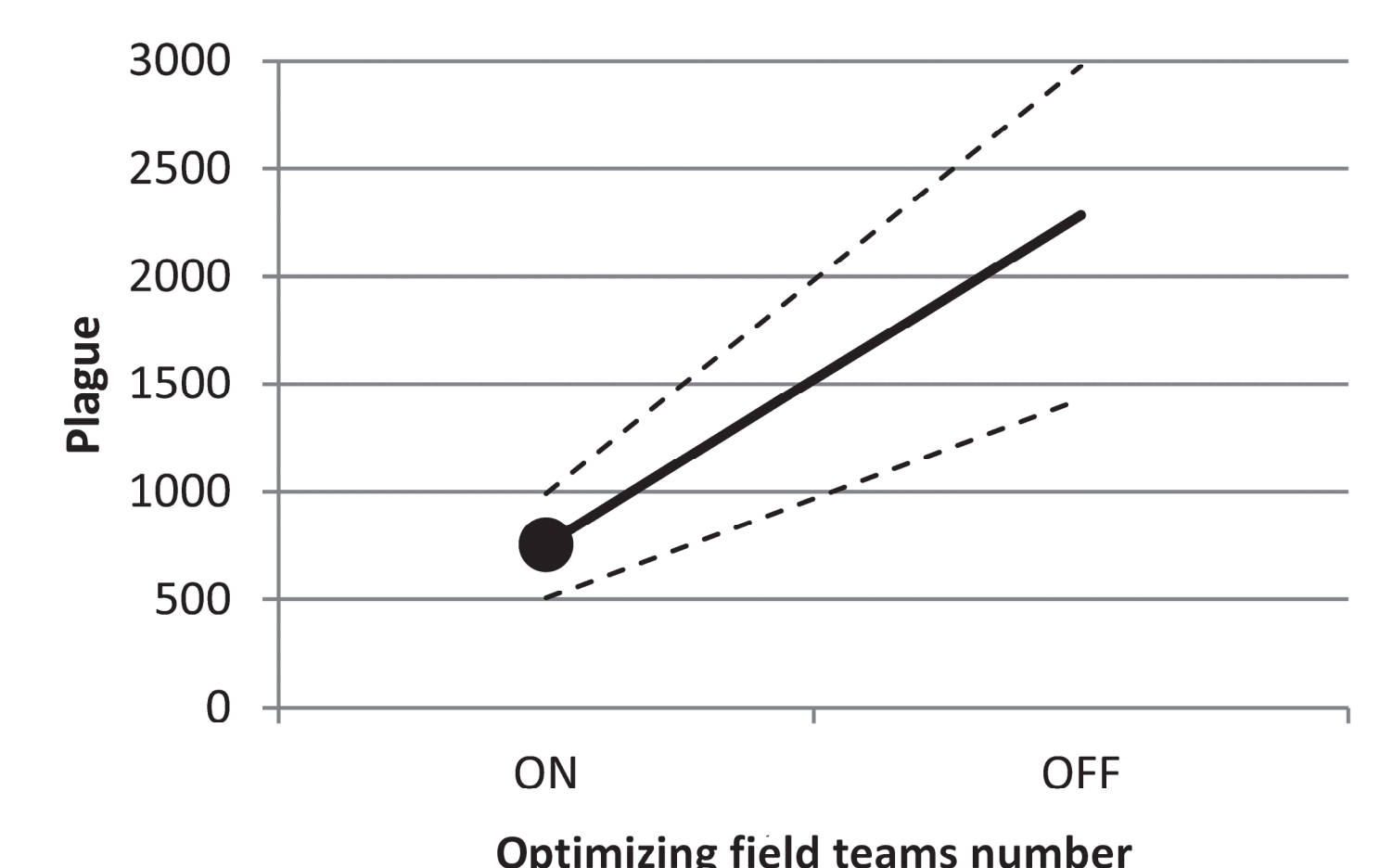
The funding institutions could clearly make the preventive management more efficient by increasing by just few percent their base of support to the control unit.

Optimizing field teams number reduces by three the risk of an invasion →

The control unit should avoid hiring too many field teams when the plagues bring money to be able to assure maintenance of surveys in recession times.



Effect of variation of the number and range of field teams movements on the plague.



Effect of variation of optimizing field teams number on the plague.

The current situation in Western Africa with improvements of information systems, stability of national anti-locust centres and rapid fund release support our findings. Some other locust-affected countries are counter-examples and our model depicts well the vicious cycles of locust plagues they are confronted with.

> CONCLUSION

Given the specificities and complexities of each locust affected region, we argue that anti-locust management should be considered as an adaptive complex system. Managers and funding institutions should integrate complexity in their decisions.